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(54) Article equipped with structural members and method for its manufacture

(57) A method of manufacturing an article equipped with structural members wherein the surface of an elongate body comprising metal or alloy is subjected to plating treatment to form a plating film of film thickness 0.001 - 10 μm, this is cut into structural members, and the structural members are then mounted on a substrate. The method provides highly decorative articles equipped with structural members of metal or metal alloy (e.g., slide fasteners or fastener chains, or clothing having buttons thereon) wherein the effect of the various types of plastic processing on the plating film is slight and furthermore, wherein there are no problems regarding product quality and function even though they are subjected to various types of plating treatment.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a method of manufacturing an article equipped with structural members and an article equipped with structural members of metal or metal alloy (e.g., slide fasteners or fastener chains, or clothing having buttons thereon). Articles equipped with structural members as referred to herein may be articles for opening and closing apertures of, for example, clothing, cases, bags, storage casings, or footwear.

2. Description of the Related Art

[0002] In a conventional method of manufacturing an article equipped with structural members of this type, described, for example, in terms of a slide fastener and its chain, slide fastener structural members were manufactured consisting of metal or alloy, and these were mounted on a side border section in the longitudinal direction of a fastener tape to constitute a slide fastener or its chain, and the article thus obtained was finally subjected to plating treatment. A known example is the technique disclosed in Laid-open Japanese Patent Application Number H. 10-18046.

[0003] With such slide fasteners or their chains, the aforementioned structural members, specifically, elements and stop members, were individually cut from an elongate material and, after being subjected to bending processing, mounted onto a tape. Furthermore, in the case of the elements, head forming must be performed by plastic processing in order to produce engagement heads. Also, in the case of the slider, the slider is manufactured by subjecting an elongate material to multi-step plastic processing and cutting the material into individual sections, and then the slider is mounted on the fastener chain. Thus, the present situation is that the fastener structural members mounted on the fastener tape must be manufactured by the prior art described above taking into account the effects of the various kinds of plastic processing described above on the plating (such as wear, exfoliation and cracking).

[0004] Also, in manufacture, the entire surface of the presented portions of the slide fasteners or their chains manufactured by the conventional method of manufacture presents a single coloration, and the elements and stop members also present the same coloration. Regarding fastener tapes, products in which various different kinds of coloring are produced are being commercialized, but, as mentioned above, their structural members are of a single coloration only, so, in highly decorative slide fasteners, further improvement in this respect is demanded. Furthermore, in order to provide such highly decorative products, it is important from the manufacturing point of view to be able to perform various types of plating treatment, yet it must be ensured that carrying out these various types of plating treatment does not give rise to any problems regarding quality or function. For example, when plating treatment, for example wet plating was performed as in the prior art, plating liquid penetrated into the fastener tape and was left behind. In some cases, in order to prevent the plating liquid from being left behind, washing treatment in a bath mixed with detergent had to be performed several times. Depending on the material properties of the fastener tape, this gave rise to the problem of impairing the feeling or sensation of quality, etc.

SUMMARY OF THE INVENTION

[0005] Accordingly, an object of the present invention is to provide a method of manufacturing an article equipped with structural members and an article equipped with structural members, wherein the effect of the various types of plastic processing on the plating film is slight, enabling a highly decorative product to be provided, and, furthermore, wherein there are no problems regarding product quality and function even though it is subjected to various types of plating treatment.

[0006] The present invention consists in (1) to (7) below.

(1) A method of manufacturing an article equipped with structural members wherein the surface of an elongate body comprising metal or alloy is subjected to plating treatment to form a plating film of film thickness 0.001 - 10 μm, this is cut into structural members, and these are then mounted on a substrate.

(2) The method of manufacturing an article equipped with structural members as described in item (1) wherein the elongate body is a linear body having a circular cross section, a modified cross section or a rectangular cross section, or a plate-shaped body having a rectangular cross section.

(3) The method of manufacturing an article equipped with structural members as described in item (1) wherein the article equipped with structural members is a slide fastener or chain thereof, the substrate being a fastener tape and the structural members being at least one of elements, stop members, a pull tab, or a slider.

(4) The method of manufacturing an article equipped with structural members as described in item (1) wherein the

substrate to be equipped with structural members is clothing, cloth or tape, and the structural members are buttons.

(5) An article equipped with structural members constituted by mounting structural members formed by cutting an elongate body comprising metal or alloy, which has been subjected to plating treatment of film thickness 0.001 - 10 μm, onto a substrate without further treating the cut faces of the structural members.

(6) The article equipped with structural members as described in item (5) wherein the structural members are at least one of elements, stop members, a pull tab, or a slider, and the substrate is a fastener tape.

(7) The article equipped with structural members as described in item (5) wherein the structural members are buttons and the substrate is clothing, cloth or tape.

[0007] The article equipped with structural members may comprise a slide fastener or its chain, or clothing to which engagement members such as or buttons, etc. are attached; in the case of a slide fastener or its chain, the structural members may comprise the elements, stop members (top and lower stop members) and pull tab, etc.; the substrate to be equipped with these substrate structural members (hereinafter, referred to as "substrate") may comprise the fastener tape. In the case where the structural members comprise a slider, the article may be the slide fastener chain. Also, in the case of clothing on which engagement members such as buttons are to be fixed, the structural members may be the engagement members such as buttons while the substrate may be the clothing or tape to be mounted on the clothing.

[0008] The elongate body may be a linear body of circular cross-sectional shape, modified cross-sectional shape or rectangular cross-sectional shape, or a plate-shaped body of rectangular cross-sectional shape. In the case of the elements, a modified cross-section wire of approximately Y-shaped cross section, or a circular (round) wire of circular-shaped cross section or a rectangular wire of rectangular cross section prior to the formation of the modified cross-section wire may be employed. In the case of the stop members, a rectangular wire whose cross-sectional shape is rectangular or a modified cross-section wire whose cross-sectional shape is approximately X-shaped may be employed. Also, in the case of the slider or buttons, a plate-shaped body of rectangular cross section may be employed.

[0009] There is no particular restriction on the material of the elongate body so long as this is metallic or an alloy, and copper alloys such as red brass, brass, or German silver, or aluminum alloys such as A5056, or A5052 may be employed.

[0010] As the technique for plating treatment, either a wet or dry technique may be employed. For wet plating, for example electrolytic plating, electroless plating, or hot-melt plating (coating), etc. may be employed. For dry plating, an ion plating method or physical vapor-phase deposition (PVD) such as a sputtering method, or chemical vapor-phase deposition (CVD), etc. may be employed. Specific examples of plating films that may be employed include Sn plating, Ni plating, Au plating, black Ni plating, Ag plating, or Cu-Sn plating, etc.

[0011] In the present invention, the plating thickness formed by the above plating treatment must be made in the range of film thickness 0.001 - 10 μm. This is because, if it is less than 0.001 μm, little benefit is obtained by coating the elongate body and, if the structural members, which have been mounted on the body, are subjected to some sort of external force, problems of wear or exfoliation, etc. arise, for example, in the case of a slide fastener, due to frictional force produced by the sliding of the slider, or, in the case of clothing equipped with engagement members such as buttons, due to frictional force occurring on the engagement action of the engagement members or due to pressing force during such action. And this is because, if 10 μm is exceeded, although this might be considered from the economic point of view, problems such as exfoliation or cracking tend to occur at the processed surface when subjected to plastic processing such as cutting processing, pressing, bending or calking. As in the case of the elements, slider or the like of a slide fastener, they tend to be worn due to considerable frictional force by sliding actions or large forces applied during processing. Furthermore, also in the case of structural members that are subjected to plastic deformation of large amount or in multiple steps, wear tends to occur. Consequently, the plating thickness formed by the above plating treatment should preferably be in the range of film thickness 0.005 - 5 μm.

[0012] As specific embodiments of the present invention, the following three embodiments may be considered; however, the present invention is not restricted to these.

[0013] Firstly, the coloration of the elongate body and the coloration of the plating may be made of different coloration; thus, decorative effect can be increased by giving different colors to the cut surfaces and the other surfaces. Secondly, the coloration of the plating may be given an appearance such as that of the conventionally employed German silver, containing Ni, by forming, on an elongate body containing Ni or not containing Ni, a plating to prevent Ni allergy on portions which may be anticipated to come into contact with the human body. Thirdly, consideration may be given to reducing the weight of the elongate body and using plating to mitigate problems such as wear which would otherwise be produced thereby.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Figure 1 is a diagram of a slide fastener to which the present invention is applied;
Figure 2 is an illustration of a method of mounting an upper stop member and lower stop member onto the slide fastener illustrated in Figure 1 and;
Figure 3 is a view showing a method of manufacturing a slider; and
Figure 4 is a view showing a method of manufacturing a button.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Specific embodiments are described below with reference to the drawings, taking slide fasteners as an example.

[0016] Figure 1 is a diagram of a slide fastener. As shown in Figure 1, a slide fastener comprises: a pair of fastener tapes 1, 1 formed with a core 2 at the edge on one side, elements 3 fixed (mounted) by calking at prescribed intervals on the core 2 of the fastener tape 1, a top stop member 4 and a lower stop member 5 fixed by calking to the core 2 of the fastener tape 1 at the upper end and lower end of elements 3, and a slider 6 which is free to slide in the vertical direction so as to effect meshing or separation of the elements 3, being arranged between opposite pairs of the elements 3. In the above, where the elements 3 are mounted on the core 2 of the fastener tape 1, the resultant article is termed a fastener chain 7. Also, as shown in Figure 3, a slider 6 shown in Figure 1 is produced by multi-stage press processing of an elongate body consisting of a plate-shaped body of rectangular cross section, and cutting this at prescribed intervals to manufacture a main slider body and furthermore, if necessary, mounting a spring and a pull tab thereon. The pull tab could be employed produced by punching out, at intervals of a prescribed shape, from the plate-shaped body of rectangular cross section, and fixing this to the main slider body by calking.

[0017] Figure 2 is a view showing a method of manufacturing the elements 3, the top stop member 4 and lower stop member 5 of the slide fastener shown in Figure 1, and a way of mounting these onto the core 2 of the fastener tape 1. As shown in this Figure, the elements 3 are produced by cutting a modified cross-section wire 8 of approximately Y-shaped cross section at intervals of prescribed dimension and forming these with engagement heads 9 by press forming; these are then mounted onto the core 2 of the fastener tape 1 by calking both foot parts 10 thereof. The top stop member 4 is produced by cutting a rectangular wire 11 of rectangular cross section at intervals of a prescribed dimension and forming the cross section into an approximately U-shape by bending processing; this is then mounted on to the core 2 of the fastener tape 1 by calking. The lower stop member 5 is produced by cutting a modified cross-section wire 12 of approximately X-shaped cross section at intervals of a prescribed dimension and then mounting onto the core 2 of the fastener tape 1 by calking. Although, in the Figure, the elements 3 and upper and lower stop members 4 and 5 are simultaneously mounted onto the fastener tape 1, in fact, first of all, the fastener chain is produced by continuously mounting the elements 3 onto the fastener tape 1, then the elements 3 of the fastener chain in the region where the stop members will be mounted are removed, and the prescribed stop 5 members 4 and 5 are mounted adjacent to elements 3 in these regions.

[0018] Figure 4 is a cross-sectional view showing a method of manufacturing a button. As shown in this Figure, an elongate body consisting of a plate-shaped body of rectangular cross section is punched out into prescribed shapes and these are used to form the surface member of the button as shown in the Figure by press forming. As shown in Figure, the button surface member is fixed by calking onto a button mounting member and this is sewn onto the clothing or the tape.

[0019] The present invention is specifically described below with reference to Examples thereof, in which plated film thicknesses in the ranges 0.001 μm to 10 μm and more particularly to 0.005 μm to 5 μm were prepared.

[0020] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from a red brass consisting of $Cu_{bal}Zn_{15}$(wt%). On the surface of each wire, a gold plating layer was formed by electrolytic plating in an acidic bath under the conditions: potassium gold cyanide 1 - 30 g/l, temperature 20 - 60°C, and current density 0.1 - 1 A/dm^2. Alternatively, a gold plating film was formed on the surface of each wire by electroless plating in an acidic bath under the conditions: potassium gold cyanide 0.5 - 8 g/l, and temperature 70 - 90 °C.

Example 2

[0021] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from a red brass consisting of $Cu_{bal}.Zn_{15}$(wt%), and, on the surfaces of these, a black nickel plating film was formed by electrolytic plating in an acidic bath under the conditions: nickel sul-

fate 75 g/l, nickel ammonium sulfate 45 - 60 g/l, zinc sulfate 8 - 38 g/l, temperature 20 - 55 °C, and current density 0.05 - 2 A/dm^2.

Example 3

[0022] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from a brass consisting of $Cu_{bal.}Zn_{30}$(wt%), and, on the surfaces of these, a black nickel plating film was formed by electrolytic plating in an acidic bath under the conditions: nickel sulfate 75 g/l, nickel ammonium sulfate 45 - 60 g/l, zinc sulfate 8 - 38 g/l, temperature 20 - 55 °C, and current density 0.05 - 2 A/dm^2.

Example 4

[0023] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from a brass consisting of $Cu_{bal.}Zn_{30}$(wt%). On the surface of each wire, a tin plating film was formed by electroless plating in an acidic bath under the conditions: tin concentration 14 - 24 g/l, and temperature 48 - 52 °C. Alternatively, a tin plating film was formed on the surface by electrolytic plating in an acidic bath, under the conditions: tin concentration 30 - 80 g/l, temperature 15 - 50 °C, and current density 2 - 100 A/dm^2.

Example 5

[0024] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from a German silver consisting of $Cu_{bal.}Zn_{24}Ni_{13}$(wt%). On the surface of each wire, a gold plating film was formed by electrolytic plating in an acidic bath, under the conditions: potassium gold cyanide 1 - 30 g/l, temperature 20 - 60 °C, and current density 0.1 - 1 A/dm^2. Alternatively, a gold plating film was formed on the surface of each wire by electroless plating in an acidic bath under the conditions: potassium gold cyanide 0.5 - 8 g/l, and temperature 70 - 90 °C.

Example 6

[0025] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross were manufactured from German silver consisting of $Cu_{bal.}Zn_{24}Ni_{13}$(wt%). On the surface of each wire, a tin plating film was formed by electroless plating in an acidic bath under the conditions: tin concentration 14 - 24 g/l, and temperature 48 - 52 °C. Alternatively, a tin plating film was formed on the surface of each wire by electrolytic plating in an acidic bath, under the conditions: tin concentration 30 - 80 g/l, temperature 15 - 50 °C, and current density 2 - 100 A/dm^2.

Example 7

[0026] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross were manufactured from A5056 consisting of $Al_{bal.}Mg_5Mn_{0.08}Cr_{0.1}Ti_{0.008}$(wt%). On the surface of each wire, a nickel plating film was formed by electroless plating in an acidic bath under the conditions: nickel sulfate 20 g/l, sodium hypophosphite 25 g/l, and temperature 90 °C. Alternatively, a nickel plating film was formed on the surface of each wire by electrolytic plating in an acidic bath, under the conditions: nickel sulfate 240 - 340 g/l, nickel chloride 40 - 70 g/l, boric acid 40 - 50 g/l, temperature 45 - 60 °C, and current density 1 - 12 A/dm^2.

Example 8

[0027] A modified cross-section wire having an approximately Y-shaped cross section and a round wire having a circular-shaped cross section were manufactured from A5052 consisting of $Al_{bal.}Mg_{2.5}Mn_{0.08}Cr_{0.17}Ti_{0.01}$(wt%), and, on the surfaces of these, a nickel plating film was formed by electroless plating in an acidic bath under the conditions: nickel sulfate 20 g/l, sodium hypophosphite 25 g/l, and temperature 90 °C. Alternatively, a nickel plating film was formed on the surface by electrolytic plating in an acidic bath, under the conditions: nickel sulfate 240 - 340 g/l, nickel chloride 40 - 70 g/l, boric acid 40 - 50 g/l, temperature 45 - 60 °C, and current density 1 - 12 A/dm^2.

(Manufacture of Samples)

[0028] Wires formed with the various types of plating films obtained by Examples 1 - 8 were cut at prescribed dimensions and subjected to press forming to obtain fastener elements 3; these were fixed by calking onto a fastener tape 1 to produce a slide fastener chain. The evaluation described below was conducted using these slide fastener chains. In the case of the round wire of circular cross section, the round wires each having the above-mentioned plating film thereon were subjected to multi-stage rolling to form into modified cross-section wires of Y-shaped cross section and subsequently used to produce slide fastener chains in the same way as ← in the case of using the modified cross-section wires.

(Evaluation of the samples)

[0029] Corrosion resistance and ornamental property were tested on the slide fastener chains which were thus obtained in Examples 1 - 8.

[0030] For the evaluation of corrosion resistance, a constant-temperature constant-humidity test was performed by exposure for two hours to an atmosphere of 90 % RH at 80 °C, and the change in color of the surfaces of elements 3 was then examined by visual observation. This evaluation was conducted before and after the test. Samples which showed a change on visual observation are indicated by the symbol X, while those which showed no change are indicated by the symbol ○.

[0031] For the evaluation of ornamental property, a slider 6 was mounted on a pair of the slide fastener chains obtained above and a test of durability to reciprocating opening and closing 3000 times was performed, after which visual observation was used to determine whether or not the base material was exposed from the plating film. In this evaluation, after the test, samples in which the base material was exposed to visual observation are indicated by the symbol X while those in which it was not exposed are indicated by the symbol ○.

[0032] These results are shown in Table 1. From the results of Table 1, it can be seen that slide fasteners and their chains manufactured by the method of the present invention have excellent corrosion resistance and ornamental property.

Table 1

Example	Plating film	Corrosion resistance	Ornamental property
1	Au plating (electrolytic /electroless)	○	○
2	Black Ni plating	○	○
3	Black Ni plating	○	○
4	Sn plating (electrolytic /electroless)	○	○
5	Au plating (electrolytic /electroless)	○	○
6	Sn plating (electrolytic /electroless)	○	○
7	Ni plating (electrolytic /electroless)	○	○
8	Ni plating (electrolytic /electroless)	○	○

[0033] Also, when these slide fastener chains were sewn onto clothing and various types of washing tests were conducted, corrosion resistance and ornamental properties were found to be excellent. Furthermore, in respect of these slide fastener chains, excellent results were obtained in characteristic evaluations including those specified in JIS (Japanese Industrial Standard) S 3015, such as crosswise strength of the chains, bending and crosswise pulling strength, top stop holding strength, sliding and pulling-out strength of the elements 3, sliding resistance, slider locking strength of the slider 6 and durability to reciprocating opening and closure (M grade) of slider 6.

[0034] Furthermore, the relationship between the properties and the plating film thickness was investigated in respect of the above examples 1 - 8. If the film thickness is less than 0.005 μm, the less the film thickness becomes, the higher the tendency of exfoliation becomes due to wear caused when the test samples were subjected to rolling, pressing and calking. Also, exfoliation more often occurs due to wear when the slider 6 was mounted and slid. Further, corrosion more easily occurs in corrosive environments. On the other hand, in the case where the thickness was more than 5 μm, with increasing the thicknesses, cracking due to processing more often occurs under rolling, pressing and calking.

(Evaluation of the Examples)

[0035] Slide fastener chains were produced using the plated wires obtained in accordance with Example 1. Further, a rectangular wire and a modified cross-section wire of approximately X-shaped cross section, and an elongate plate, all plated, were prepared in the same procedures as described in Example 1 and upper and lower stop members 4,5 and sliders 6 were formed respectively. These stop members and sliders were mounted and fixed onto the above-mentioned slide fastener chains by calking to provide slide fasteners. With the slide fasteners that were thus obtained, cut faces had a red brass color, but the surface regions of all of the structural members were of gold color produced by gold plating; thus, the portions that were exposed to outer view presented a gold color, providing excellent ornamental properties.

[0036] Slide fasteners were produced in as described above using materials prepared in accordance with Examples 2 and 3. In the slide fasteners that were thus obtained, the cut faces were of red brass or brass color but all of the surface portions of the structural members were of black nickel, produced by the black nickel plating; thus, the planar portions that were exposed to outer view presented a black nickel color, while the red brass or brass color of the cut faces was displayed depending on viewing angle; by the contrast of these, excellent ornamental properties were obtained.

[0037] Slide fasteners were produced as described above, using the materials prepared in accordance with Examples 4 and 6. With the slide fastener that was thus obtained, while the base material was of brass or German silver color, all of the surface portions of the structural members were of white color like German silver, produced by the tin plating; thus, when used as a slide fastener, portions that are in contact with the body are protected by the tin plating, so an anti-nickel slide fastener having a color tone like German silver can be produced. However, when the possibility of exfoliation, cracking, or wear of the plating film is taken into account, brass or red brass as described above are preferable as base materials. Also, in this case, there is not much difference of coloration between the base material and the plating film, so even if there is some exfoliation, cracking or wear, it does not cause any particular problems regarding coloration.

[0038] Slide fasteners were produced as described above, using materials prepared in accordance with Example 5. With the slide fasteners that were thus obtained, the cut faces were of German silver, but the surface regions of all of the structural members were of gold color produced by gold plating; thus, the planar portions that were exposed to outer view presented a gold color, and the German silver color of the cut faces was displayed depending on viewing angle. Thus, excellent ornamental properties were provided by the contrast of these, just as in the case of Examples 2 and 3.

[0039] Slide fasteners were produced as described above, using the materials prepared in accordance with Examples 7 and 8. With the slide fasteners that were thus obtained, the base material consisted of aluminum alloy, thereby enabling weight reduction of the slide fastener to be achieved. Also, since a nickel plating film was formed at the surface portions that were presented to view, a high-class impression was presented, and the product was of excellent wear resistance.

[0040] With the method of manufacture according to the present invention, thanks to the restriction of the thickness of the plating film, the structural members can be manufactured after plating treatment and these can be mounted onto the substrate; also, an article equipped with these structural members can be provided thereby wherein even if this is subjected to cutting processing or plastic processing, there is no detrimental effect of the processing on the plating. Also, since the coloration of the structural members in portions that are presented to view can be changed and the structural members can be mounted on the substrate after plating treatment, mounting can also be effected choosing structural members of different coloration. Furthermore, since structural members after plating treatment are mounted on the substrate, the substrate is not subjected to the effect of the plating treatment, making it possible to provide products which fully exploit the characteristic features which this material possesses.

Claims

1. A method of manufacturing an article equipped with structural members wherein the surface of an elongate body comprising metal or alloy is subjected to plating treatment to form a plating film of film thickness 0.001 - 10 μm, the plated elongate body is cut into structural members, and the structural members are then mounted on a substrate.

2. The method of manufacturing an article equipped with structural members according to claim 1 wherein the elongate body is a linear body having a circular cross section, a modified cross section or a rectangular cross section, or a plate-shaped body having a rectangular cross section.

3. The method of manufacturing an article equipped with structural members according to claim 1 wherein the article equipped with structural members is a slide fastener or chain thereof, the substrate to be equipped with structural members being a fastener tape and the structural members being at least one of elements, stop members, a pull

tab, or a slider.

4. The method of manufacturing an article equipped with structural members according to claim 1 wherein the substrate to be equipped with structural members is clothing, cloth or tape, and the structural members are buttons.

5. The method of claim 1, 2, 3 or 4, wherein the film thickness is from 0.005 μm to 5 μm.

6. An article equipped with members, constituted by mounting onto a substrate (1) structural members (3,4,5,6,14) formed by cutting an elongate body (8,12,13) comprising metal or alloy that has plated with a film of thickness 0.001 - 10 μm without further treating the cut faces of the structural members (3,4,5,6,14).

7. The article equipped with structural members according to claim 5 wherein the structural members are at least one of elements (3), stop members (4,5), a pull tab, or a slider (6), and the substrate is a fastener tape (1).

8. The article equipped with structural members according to claim 5, wherein the structural members are buttons (14,15) and the substrate is clothing, cloth or tape.

9. The article of claim 6, 7 or 8, wherein the plated film thickness is from 0.005 μm to 5 μm.

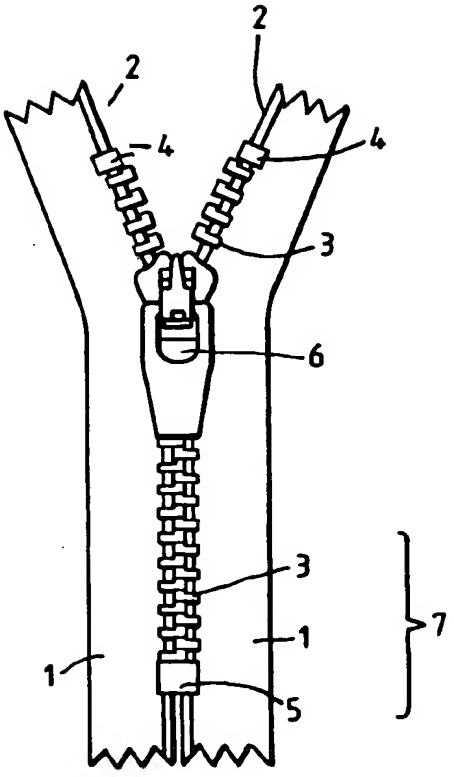

Fig. 1

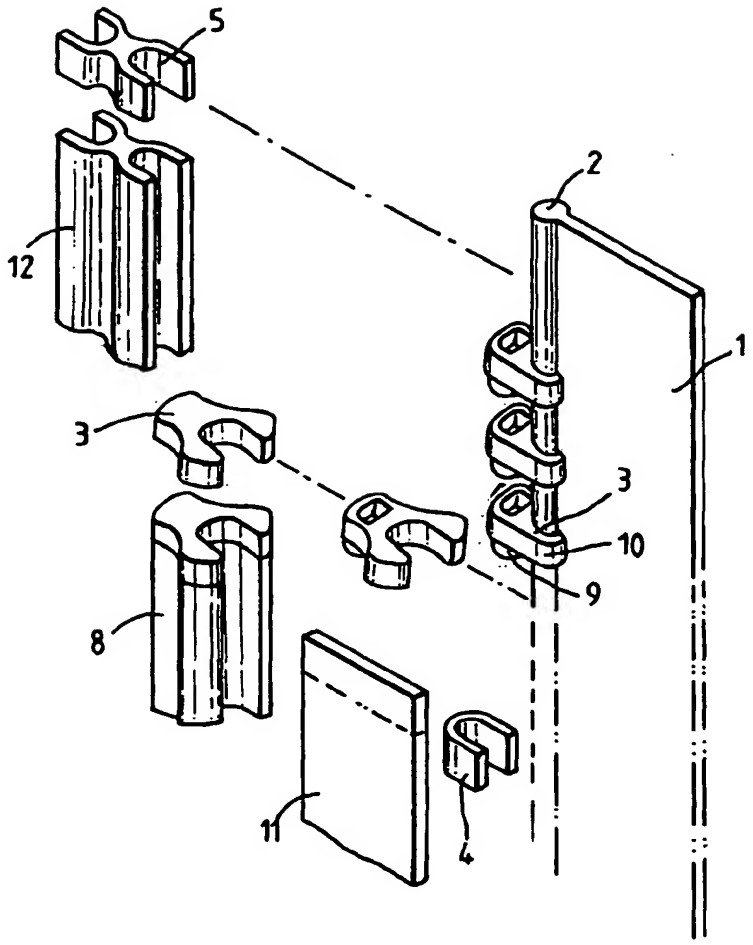

Fig. 2

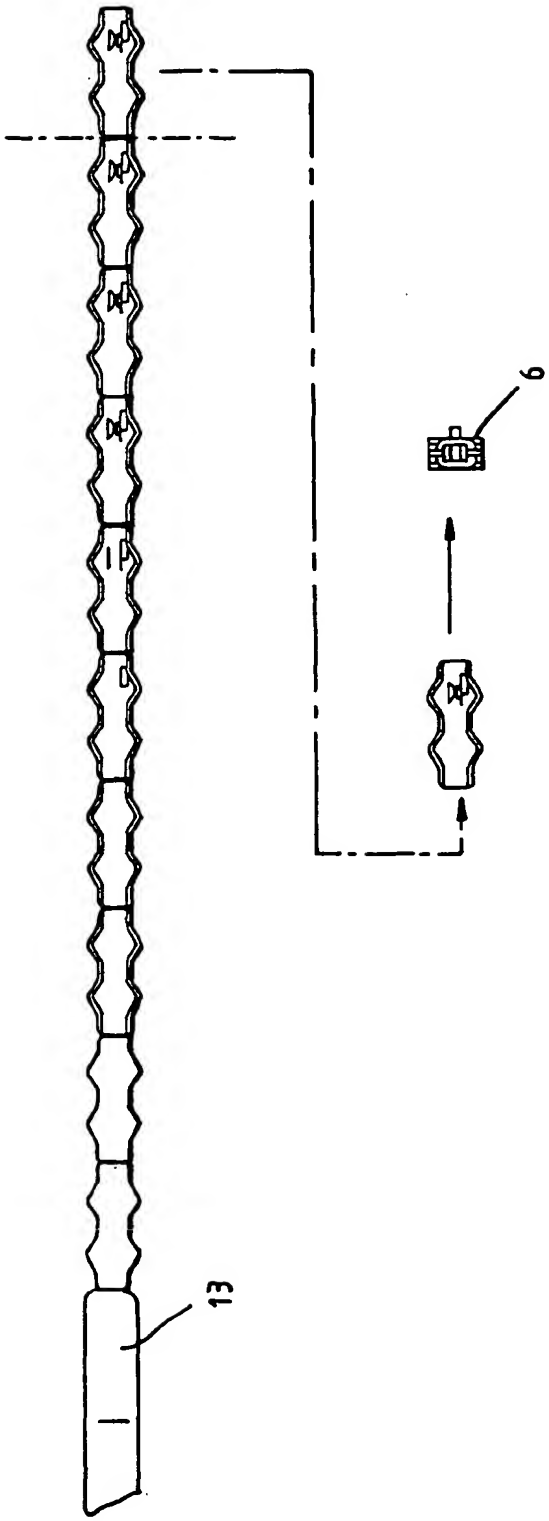

Fig. 3

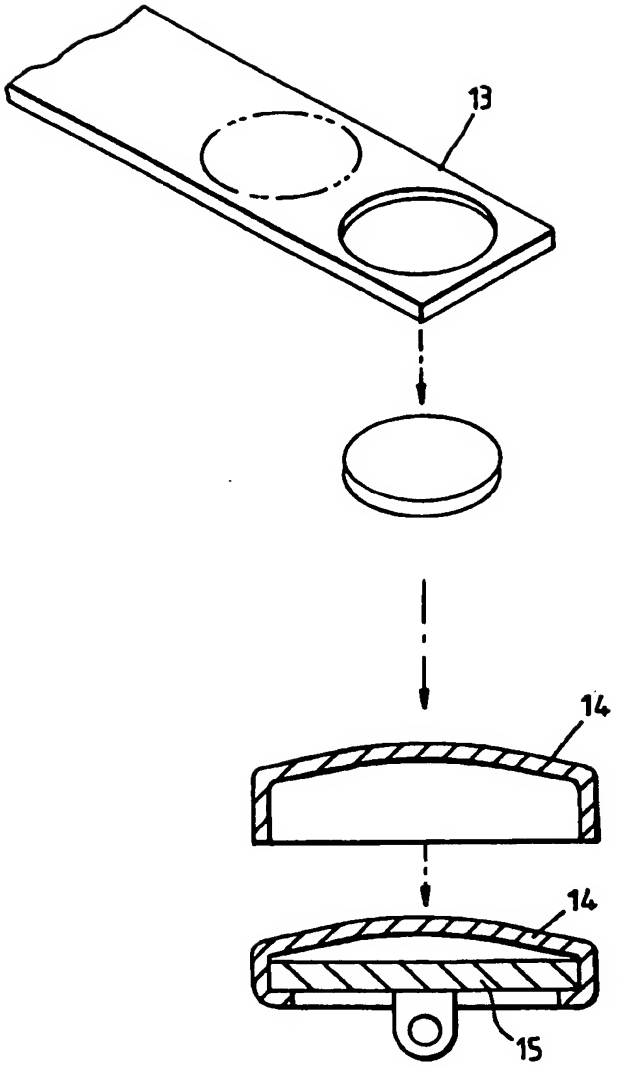

Fig. 4